TREX13: Mid-Frequency Measurements and Modeling of Scattering by Fish

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LONG-TERM GOALS

To quantify properties of mid-frequency acoustic reverberation in terms of the physical and biological properties of the environment. The results will improve the ability to predict sonar performance.

OBJECTIVES

This component of the TREX13 program concerns characterizing the contributions of acoustic scattering by fish to the reverberation. The clutter characteristics of the fish will also be quantified.

APPROACH

The research is based, in part, on a large multi-PI experiment that took place in April/May, 2013 off of Panama City, Florida. The program is led by APL:UW (Tang/Heffner) and details of the experiment are in their report. A key element of the fish component was the measurements of mid-frequency reverberation from a fixed source and receiver. The measurements were made nearly continuously, 24 hours per day. Another key element to the fish effort is the UW-led (Horne) high frequency surveys of fish in the area. The WHOI-led (Stanton) effort focusses on analyzing and modeling the mid-frequency reverberation data in terms of the fish that were presumed present. Modeling will be in terms of the fish patchiness, sonar parameters, and physical (waveguide) environment. Contributions to the reverberation and clutter by the fish will be characterized. Stanton oversees this fish component of the research and participates in all phases of the research. Jones conducts data analysis and modeling of the fish echoes. The analysis includes characterizing the echoes in terms of their spectral content and statistics. The modeling includes taking into account waveguide effects and other

environmental properties that affect propagation and scattering of a long-range sonar signal. These efforts will be leveraged by those of other PIs in the TREX13 program through participation in regularly scheduled workshops.

WORK COMPLETED

No new funding was awarded this year. As a result, there was minimal progress.

With the funds remaining from the previous year, Stanton participated in the TREX13 workshop in Indianapolis and did some followup work. The participation included 1) giving a presentation on progress in FY14 and 2) making plans, pending new funding, for analyzing fish-echo data being made available by APL:UW. According to APL:UW, approximately 50% of the long-range acoustic reverberation data collected in the TREX13 experiment contained echoes from fish significant enough to contaminate the reverberation data from the seafloor. Plans were made during the workshop and as part of followup tasks to analyze those data in terms of 1) the energy of the fish echoes relative to that from the seafloor, 2) echo statistics associated with the fish echoes and the degree to which those statistics are non-Rayleigh, and 3) the fraction of fish echoes being reverberation-like vs clutter-like.

RESULTS

The TREX13 measurements summarized in the workshop illustrate the spatial and temporal variability of mid-frequency echoes due to the presence of fish. They also illustrate the importance of accounting for fish echoes, as these echoes dominated echoes from other sources (seafloor and sea surface) in spite of the fact that this was a shallow waveguide with many echoes from both boundaries. Specifically, as reported by APL:UW, approximately 50% of the long-range acoustic reverberation data contained echoes from fish significant enough to contaminate the seafloor-echo data.

The fish echoes occurred only at night, varied from night to night (and not being significant some nights), and varied within a night. Very importantly, the fish were shown to migrate horizontally at night. This observation, in combination with the fact that the scattering by fish near a boundary can change significantly (increase or decrease, depending on their resonance frequency), may help to explain why there are negligible fish echoes during the day. That is, during the day, the fish may have either moved out of the region or moved to the seafloor.

Also, on a related note, the diurnal pattern of noise observed in the mid-frequency band is also presumed to be related to the presence of fish, as they are not only scatterers of sound, but they are also producers of sound. It is probably a different type of fish that scattered sound vs produced the sound.

What makes all of these results special is the controlled nature of the reverberation experiments and associated characterization of the environment. Because of the control, the environmental properties can be accounted for in the modeling of the acoustic propagation and scattering and the fish-echo data can be studied with greater accuracy (fewer unknowns) than in other previous studies.

Pending new funding, we remain positioned to conduct a more in-depth analysis of modeling propagation effects, apply an energy normalizer to the data (such as the one used in Navy sonar signal processors), and calculate echo statistics (including probably of false alarms).

IMPACT/APPLICATIONS

These results add to the growing body of evidence of the importance of fish in the performance of sonars—both active and passive sonars. The spatial and temporal variability of the fish will cause a correspondingly variable effect on the performance of sonars. Depending on the size and degree of heterogeneity of the fish distributions, the fish echoes will either be a source of "clutter" (i.e., target-like) or reverberation (i.e., background-like), each which affect the performance of ASW systems.

These data are consistent with the pattern of significant changes in reverberation and clutter as observed in Navy surface ship mid-frequency active systems.

RELATED PROJECTS

This research builds on the methods that Stanton, Jones, and colleagues developed in two other former ONR programs: 1) ONR MMB/NOPP project (N00014-1-10-0127) in which mid-frequency fish-echo data were collected in a complex propagation environment (Gulf of Maine) and 2) HiFAST FNC program in which fish echoes were simulated for use in Navy sonar trainers (SAST-NAVSEA and CASE-NAVAIR). In each program, simulation tools were developed to describe various aspects of fish echoes (spectral and statistical) as a result of long-range propagation of a mid-frequency acoustic signal in a complex ocean waveguide. The HiFAST program has resulted in two transitions completed so far (SAST ACB13 and CASE), with one more approved and in progress (SAST ACB15).